**Solubility with change in pH**

**1)** The solubility of zinc hydroxide, Zn(OH)2, can be altered by changes in pH. Some changes in pH may

lead to the formation of complex ions, such as the zincate ion, [Zn(OH)4]2–

Use equilibrium principles to explain why the solubility of zinc hydroxide increases when the pH is less

than 4 or greater than 10.

*No calculations are necessary.*

**2) a)** Some sulfides have very low solubility products. When hydrogen sulfide gas is bubbled through solutions of these ions, these ions separate from a mixture of ions.

**i)** In a saturated solution of hydrogen sulfide [H3O+]2[S2–] = 1.10  10–23 Calculate the sulfide ion concentration when the pH of the solution is 4.20.

**ii)** Calculate the solubility of FeS in this solution, in mol L–1. *K*s(FeS) = 4.90  10–18

**3)** A solution contains a mixture of the two metal ions Cu2+ and Zn2+, both of the same concentration. The solution is saturated with hydrogen sulfide and adding hydrochloric acid lowers the pH of the solution.

*K*s(CuS) = 6.30  10–36 *K*s(ZnS) = 1.6  10–24

Account for the fact that at a pH close to 7 all the metal sulfides will precipitate whereas only the most insoluble sulfides precipitate out at a lower pH. In your answer, you should use equilibrium principles and both Cu2+ and Zn2+ as examples.*(No calculations are required.)*

**4)** Discuss the effect of decreasing the pH of the water on the solubility of Fe(OH)3.

**5)** A saturated solution of zinc hydroxide, Zn(OH)2 contains a small amount of solid Zn(OH)2 at the bottom

of the container. The pH of the solution is increased. Discuss the effect of increasing the pH on the amount

of solid present, and also on the nature and concentration of the species present in the solution.

*No calculations are necessary.*

**6)** Discuss how the solubility of Ag2CrO4 will change if it is dissolved in 0.1 mol L–1 NH3

*No calculations are necessary.*

**7)** The *K*s of aluminium hydroxide, Al(OH)3, at 25°C, is 3 × 10–34, indicating that it has very low solubility. The solubility may be altered by changes in pH (due to acidic or basic properties) and formation of complex ions such as the aluminate ion, [Al(OH)4]–.

Discuss why aluminium hydroxide becomes more soluble in aqueous solutions that have a pH less than 4, or a pH greater than 10. In your answer include:

• the equation for the reaction that relates to *K*s(Al(OH)3)

• equations for the reactions that relate to changes in the solubility of aluminium hydroxide at pH less than 4

or greater than 10

• a discussion of the equilibrium principles involved.

**8)** An aqueous ammonia solution has a pH of 10 and when phenolphthalein indicator is added it turns pink. Solid ammonium chloride is added to this solution and the solution turns colourless due to a decrease in pH. By considering the equilibrium systems, discuss why the pH of the solution decreased.

Include a relevant equation in your answer.

**9)** **a)** Sea-water contains appreciable amounts of ions other than Na+ and Cl–. As part of the process for extracting table salt from sea-water, sodium hydroxide is added to the sea-water to precipitate the magnesium ions as magnesium hydroxide. The concentration of Mg2+ ions at this stage is 0.555 mol L–1. Calculate the minimum hydroxide ion concentration and hence the pH of the solution needed for precipitation to occur.

*K*s (Mg(OH)2) = 7.10 × 10–12

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